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SEALING PONDS AND RESERVOIRS WITH CLAYS 1/

By

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A fundamental property of soil is its permeability to water. Permeability is, in turn, determined by several basic conditions. One of the most important is the size of the soil pores. Excessive seepage occurs in soils that contain large pores. For example, sand contains pores of sufficient size to pass large volumes of water. Reservoirs or ponds built in such soils usually lose large amounts of water. Water loss is reduced to a minimum, however, when the large pores in sands are filled with fine particles of silt and clay.

Another fundamental principle affecting the permeability of soil to water is the driving force behind the water. The deeper the water, the greater the force that drives the water through the soil. Storage structures that hold water at great depths must have bottoms and walls that are compact and stable to prevent excessive leakage or failure of the structure. On the other hand, structures that hold shallow depths of water do not require such compact and structurally stable bottoms and walls.

The principles of sealing with clays discussed in this paper are for sealing sandy ponds and reservoirs that can tolerate small amounts of seepage and that involve small heads of water of up to 10 feet in depth.

The methods of sealing outlined in this paper came primarily from research studies by the author. This paper includes the summation of three studies. The first study was a laboratory evaluation of clay sealants. This involved measuring the physical, chemical and mineralogical properties of clay sealants as well as determining the effects of water quality upon clay sealants. The second study was a laboratory model study used to test methods of sealing and to measure performance of various sealants. The final study was a field evaluation of the best sealants. Seals were installed in the field by various methods and were evaluated over an 8-year period. In addition, the author has given assistance in sealing various reservoirs and ponds in the West. Therefore, this paper summarizes the results of 10 years of research and experience.

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TYPE OF CLAY SEALANTS

Clay sealants have three basic properties that regulate water flow. These are: (1) particle size, (2) chemistry, and (3) mineralogy. Clay is small in size (less than .002 mm) and contains very small pores which conduct but little water. This is particularly true if the clay particles are separated from each other. Chemistry of the soil particle usually regulates particle separation, often referred to as dispersion. Sodium salts commonly cause dispersion of clay particles.

Mineralogy of the clay can also influence water movement. For example, montmorillonite is a high swelling clay mineral. High swelling further decreases soil pore size and gives a clay the final requirement of an effective sealer. For more details on clay mineralogy, see the section on water quality.

Bentonite

Bentonite is commonly used as a clay sealant. It has all of the fundamental properties of an effective sealer: (1) small sized particles, (2) dominated by sodium, and (3) has a swelling type clay mineral (montmorillonite). This clay can swell up to 15 times its dry volume when wetted. This makes the voids that transmit water extremely small. Because of these properties, it requires only small amounts of bentonite to impede water movement.

Bentonite is available commercially. It is usually ground to various sizes and bagged for ease of handling. Particles from 20 to 70 mesh size are commonly bagged together. But, it is possible to install a seal with the unground (pit-run) material if it can be crushed and placed smoothly at the sealing site by some method. Weathering, particularly wetting and drying, can sufficiently reduce large sized particles to successfully install a surface seal. Disking can also reduce the large clods to a suitable size to form a smooth, even seal.

Playa Sediments

These are old dry lake bed sediments. They are found in the closed basins of the western United States. Such clays represent a large supply of low cost clay sealers.

Besides their low cost and easy access (when dry), playa clays offer various types of clay minerals. Some of these sediments contain low swelling clay materials such as mica and koalinite. Recent work by the author has shown that low swelling clay minerals seal better than high swelling clay minerals (montmorillonite) when hard waters are involved.

Conversely, playa clays of the high swelling type often meet the sealing requirements of bentonite, since they are small in size and contain sodium (usually in excessive amounts). Therefore, do not overlook the possibility of a playa sediment as a source of sealant.

Most playa sediments will load very easily with a front-end mounted loader. Machinery,or hand spreading can be used at the sealing site to distribute the clay.

Local Clay

Local clay, other than playa sediments, near the sealing site can also be an effective sealer if enough is available and if the seal is properly installed. Local clays may not contain sodium as a dispersing agent and therefore may require compaction to form an effective seal. Earth linings (of sufficient clay content) can be effective sealers if compacted at the proper moisture content regardless of their chemistry and mineralogy. Such linings should contain at least 15 percent clay and silt sized particles; otherwise, compaction would not reduce their permeability.

WATER QUALITY

Before choosing a clay sealant, water quality must be considered if the clay is to be placed without the benefit of livestock trampling or mechanical compaction. Hard waters will flocculate many high swelling clays, increasing the size of voids and causing the clay to become more permeable. Hard waters are waters high in calcium and magnesium, or waters high in total salts of any type. If these waters are encountered, it should be known how the clay will react to the water, to avoid failure of the seal.

Placing seals in stock watering ponds is an exception. Livestock will puddle or compact a soil, depending upon the degree of wetness. Clays become puddled if trampled when saturated, and compacted when moist. Both processes reduce the permeability of the soil. Compaction may be needed in the center of large stock ponds, where livestock may not trample too often. But, many low swelling clays will perform satisfactorily without compaction. Playa sediments containing low swelling clays have been shown to retain effective seals when leached with hard waters for long periods of time. But this is not true for all clays.

Therefore, knowledge of water quality and clay sealant reaction is desirable to place an effective seal. A simple test may be all that is required. If the clay will remain suspended (in the water involved) for several weeks, or more, the clay should form an effective seal.

METHODS OF SEALING

Waterborne

There are several methods of adding clays to sandy soils to lower their seepage rates to tolerable levels. One of the simplest methods is by adding clay to the water. This is commonly called a waterborne treatment. Dispersing the clay in the water is all that is required.

Methods of dispersion vary from just throwing the clay into the water to elaborate and more thorough mixing equipment. A venturi-jet mixer attached to a pump will disperse pelleted clays (20 to 70 mesh) very well. Finely powdered clays (200 mesh) do not mix well. An application rate of one pound of clay per each square foot of soil will seal most soils.

But, this sealing method may be short-lived if conditions are not ideal. This method is suited to sandy soils that have less than 10 percent silt and clay sized particles. Shallow seals will develop in soils that contain more than 10 percent silt and clay. Clay penetration of 2 inches or more, during the sealing treatment, is important to develop a successful seal. Shallow seals can be subject to erosion and damage from drying. Drying of some clays at shallow depths can cause cracking which may not reseal when rewetted.

Sands especially suited for sealing with waterborne clays are most likely found in newly constructed ponds or reservoirs. Sandy soils without fine particles are not apt to be found in older structures since they tend to accumulate silt with time. Such sealing by siltation is a natural process if suspended soil particles are present in the water, and they usually are present.

The waterborne treatment would be most useful when emergency sealing is needed, such as during a drought. Much needed water could be saved during times of temporary water shortage with a rapid treatment of waterborne clays. It might pay to seal with waterborne clay, even if the seal would only be temporary.

Surface Blanket

Another method is to spread the clay over the soil surface or to mix the clay into the soil. This is the recommended method for sealing stock watering ponds. A simple but effective seal is placed by spreading the clay on the soil surface and then allowing the livestock to trample the sealant into the soil.

If a deeper seal is desired, the clay can be mixed into the surface soil. This will usually be a more effective seal. It will be more resistant to erosion or damage from drying. Harrowing or disking could give suitable mixing. Three or four pounds of clay per square foot of soil, mixed into 3 or 4 inches of soil, will provide a good seal. A general rule is to add one pound of clay to each square foot of soil surface for each inch of seal depth. For example, a four-inch seal will require 4 pounds of clay for each square foot of soil surface.

Buried Membrane

The most effective clay sealing method is to bury a continuous compact layer of clay under a cover of earth. This is called a buried membrane seal. Such a seal is protected from erosion as well as drying or even freezing. About the only thing that can damage such a seal is burrowing animals or, for some types of clay, waters very high in calcium or magnesium, as mentioned before under Water Quality. Even with such hard waters, leakage may not occur (for some clays) until the clay has been dried. If covered properly, and wetted occasionally, sufficient drying may never occur to damage the seal.

An effective buried membrane seal can be installed by first preparing a smooth, compact subgrade. Clay should then be spread smoothly over the area. Clays low or void of sodium may require compaction to form a dense impermeable layer. Clays high in sodium will not require compaction if large clods are crushed before placing the seal.

If local clays are used, a 3-to-4-inch layer may be required. But, if commercial bentonite is used as the sealing membrane, about 4 pounds of clay per square foot of soil surface will form an effective seal if the bentonite is spread at an even depth. This application rate will form a ½-inch layer of dry clay. But this will expand to about a 2-inch thickness when wetted and under about a 6-inch blanket of earth. A 6-inch cover over this seal will provide adequate protection from drying or freezing in many areas. Earth excavated from the site before seal installation can serve as the covering blanket.

This sealing method is suited to sealing structures that should be nearly water tight. Seals installed under normal conditions will seep 0.01 or 0.02 foot per day. Livestock should not be allowed to trample this seal.

ADDITIONAL HINTS ON SELECTING A SEALER

There are two obvious factors to consider in selecting a clay sealant.

1. The structure to be sealed.
2. The type of sealant available.

Both of these factors will also determine the method of sealing.

Let's briefly consider the structure to be sealed. Livestock watering ponds have one major requirement of a clay sealer. It should be high in clay sized particles. Mineralogy and chemistry of the clay is not important because trampling by the animals will keep the clay sealant puddled or compacted, depending upon the degree of wetness.

Storage ponds and reservoirs that are not trampled by livestock have more rigid requirements of a clay sealer. Mineralogy and chemistry of the clay must be considered since the seal must hold up without the benefits of livestock trampling. In such cases, the quality of the water being stored determines the mineralogical and chemical requirements of a clay sealer. (See preceding discussion on water quality.) Mechanical compaction, however, can override the wrong mineralogy or chemistry of a clay. Using a particular sealer in such cases then becomes a matter of economics, with the added cost of mechanical compaction. (See section on seal maintenance for more details on compaction.)

Now let us consider the type of sealant available. This can also be a matter of economics. Transportation is usually the greatest cost of a clay sealer. For this reason, local clay sources should be explored first. Local clays are especially suited for livestock watering ponds, since mineralogy and chemistry of the clay is not critical, due to livestock trampling, as before mentioned.

But playa clays or bentonites are usually better sealers and less is required to form an effective seal. So consider the amount of clay to be moved in the total cost. Also, consider other aspects of transportation carefully. The clay should be close enough to the sealing site so that transporting costs are reasonable. It must also be accessible, and the clay must be sufficiently dry at some time during the year to allow equipment mobility. This can be critical with playa sediments.

A good clay sealant is high in clay sized particles and low in sand. The clay should be sticky when wetted. A simple but more

precise test can be made by dispersing some of the sealant in water. A high percentage of a sample should stay in suspension after it is shaken in softened water. Allow 2 hours for each one inch of water depth to settle out silt sized particles. Clay sized particles may stay in a water suspension for weeks or months, the longer the better.

Between 20 and 50 percent silt is desirable in a clay sealant to avoid the cost of crushing or grinding. Such a silt content causes the material to break up well when handled. Loading and unloading will usually break the sealant up enough to allow placing a smooth seal of even depth.

A simple test to determine the physical structure of a prospective clay sealant is to turn it over with a hand shovel. If it breaks up well, it will form a smooth seal of even depth without further crushing or grinding.

A further clue to the sealing property of a clay is to observe it following a rainfall. If it sheds water readily, or accumulates water in depressions for long periods of time, it will usually be a good sealer. A playa that holds water for a long time will be a good sealer.

Sealing Costs

Sealing costs can vary greatly, according to local availability of sealant, labor and equipment. Table 1 lists expected sealing rate, approximate cost, and estimated life of the three basic methods of sealing with clays. The costs shown are for playa clays or local clays shipped 20 to 30 miles.

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Table 1. Expected seepage rate, cost and estimated life of three methods of sealing with clays.

Sealing method	Seepage rate 1/ (ft/day)	Cost per sq.yd. 2/ $	Estimated Life Yrs.
Waterborne	.05 to .15	0.20	1 to 3
Surface blanket (4-inch)	.01 to .10	0.40	4 to 5
Buried membrane (3-inch)	.01 to .05	1.10	8 to 12

1/ Expected seepage rate under normal conditions.
2/ Cost will vary with local cost of sealant, labor and equipment.

Precautions

Before installing a blanket or membrane seal, take care to shape the walls of the structure to a proper slope. Slopes should be 1½ to 1 (run to rise) or flatter. Steeper slopes can cause slippage and rupturing of the seal.

It is important to place the clay at an even depth over the entire structure. If some areas are missed, or the seal is too thin, highly porous structures may behave as though they have not been sealed.

Take care, in gravel soils, to provide sufficient soil mantle for the sealant to rest upon. Soils with large voids such as gravels will not give sufficient support to the seal and will "blow out" causing failure of the seal. Such coarse material should be covered with several inches of sand or finer earth before placing the clay seal.

Wave action caused by wind can be damaging to surface seals. In such cases, the wall of the pond receiving the prevailing winds may need a covering blanket over the seal. Gravel is preferred, but finer earth of 6-inches depth, or more, would give adequate protection in many situations.

SEAL MAINTENANCE

An advantage of using clay sealants is the simple maintenance required. A leaking seal can be restored by one of two simple methods: (1) add more clay, or (2) compact.

Adding more clay would be an effective way to rejuvenate surface seals and might even work to plug cracks in buried seals.

Compaction is particularly suited to renew clay seals, especially surface seals. Even in sandy soils, if sufficient clay has been added, it will tighten when compacted. Compaction can be accomplished by two methods: livestock and mechanical. Ponds or reservoirs not ordinarily trampled by livestock could be effectively compacted by driving, salting, or feeding livestock in them when the soil is moist.

Mechanical compaction is a more exact operation. First, some type of equipment should be used to apply the proper force. And second, maximum compaction will only be reached when the clay is at an optimum moisture content. The optimum moisture content can usually be estimated by forming a hand cast of the soil. If the cast will hold firm, without showing free water, it should compact well.

LITERATURE ON CLAY SEALING

Bowman, C. C. The Sealing Effects of Bentonite and Clay Soils under Extreme Conditions. Mont. Agr. Exp. Sta. Bul. 610, Jan. 1967.

Dirmeyer, R. D. Sealing Rocky Ditches with Clay (or Bentonite). Colo. Ext. Service Cir. 203-A, April 1962.

Howard, S. W. Sealing Ditches and Ponds with Bentonite. Mont. Ext. Ser. Circ. 1064, (no date).

Kelley, H. J., et. al. Use of Washington Bentonite as a Hydro-seal. The Trend in Engineering. 8(4):5-11., Oct. 1956.

McNamee, M. A. Bentonite Sedimentation Process., Wyo. Agr. Ext. Ser., Mimeo Cir. 18, Feb. 1958.

Rollins, M. B. Sealing Sands with Waterborne Bentonite. J. Irr. and Drain. Div., Proc. Amer. Soc. Civil Eng. 93:24-44, Dec. 1967.

Rollins, M. B. and A. S. Dylla. Bentonite Sealing Methods Compared in the Field. J. of Irr. and Drain. Div., Proc. Amer. Soc. Civil Eng. 96: 193-203, June 1970.

Shen, R. T. Sealing Farm Ponds and Reservoirs with Bentonite. Colo. Ext. Serv. Cir. 206-A, May 1962.

Shen, R. T. Testing Bentonite for Sealing Purposes. Colo. Ext. Ser. Cir. 205-A, August 1959.

Shen, R. T. Mixing Bentonite for Sealing Purposes. Colo. Ext. Ser. Cir. 204-A, April 1959.